



Enabling local public health adaptation to climate change

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ABSTRACT

Local public health authorities often lack the capacity to adapt to climate change, despite being on the ‘front lines’ of climate impacts. Upper-level governments are well positioned to create an enabling environment for adaptation and build local public health authorities’ capacity, yet adaptation literature has not specified how upper-level governments can build local-level adaptive capacity. In this paper we examine how federal and regional governments can contribute to enabling and supporting public health adaptation to climate change at the local level in federal systems. We outline the local level’s self-assessed adaptive capacity for public health adaptation in Canadian and German comparative case studies, in terms of funding, knowledge and skills, organizations, and prioritization, drawing upon 30 semi-structured interviews. Based on interviewees’ recommendations and complemented by scientific literature, we develop a set of practical measures that could enable or support local-level public health adaptation. We find that adaptive capacity varies widely between local public health authorities, but most report having insufficient funding and staff for adaptation activities. We propose 10 specific measures upper-level governments can take to build local public health authorities’ capacity for adaptation, under the interrelated target areas of: building financial capital; developing and disseminating usable knowledge; collaborating and coordinating for shared knowledge; and claiming leadership. Federal and regional governments have an important role to play in enabling local-level public health adaptation, and have many instruments available to them to fulfill that role. Selecting and implementing measures to enable local public health authorities’ adaptive capacity will require tailoring to, and consideration, of the local context and needs.

1. Introduction

Climate change is already exacerbating existing public health problems and will continue to over the coming decades (McMichael et al., 2015). Climate change impacts health directly through morbidity and mortality associated with extreme weather events (e.g., droughts, floods) and indirectly, mediated by natural and human systems (e.g., infectious diseases, air pollution, mental health, food security) (Smith et al., 2014). Impacts of climate change on human health and wellbeing mainly happen where people live and work, at the local level. All levels of government must adapt to reduce the health burden associated with climate change, where adaptation refers to “the process of adjustment to actual or expected climate and its effects, in order to moderate harm

or exploit beneficial opportunities” (Field et al., 2012). Climate change adds additional complexities compared to other public health issues (Frumkin et al., 2015). Public health adaptation can be constrained by the uncertainty of climate change impacts, lack of financial resources, access to and use of technology, insufficient social capital, individual knowledge and perceptions, and the prioritization of more immediate public health challenges such as physical inactivity and poverty, and fragmented institutional arrangements (Huang et al., 2011; Roser-Renouf et al., 2016).

The division of roles and responsibilities for adaptation are frequently complex and undefined (Nalau et al., 2015). Though previously the mantra of “mitigation is global, adaptation is local” was common, researchers are questioning this assumption as it places responsibility

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for adaptation on local governments whose budgets are least able to absorb the costs of adaptation (Nalau et al., 2015; Burton, 2011), and overlooks the fact that adaptation is often constrained or enabled by processes over which local communities often have limited control (Amundsen et al., 2010; Measham et al., 2011). In complex governance systems such as federations, allocating responsibilities for adaptation can be challenging, as authority for public health is often shared across levels or belongs to regional governments (Banting et al., 2002). Nonetheless, local public health authorities are uniquely positioned to hold a large role as a key collaborator and initiator in reducing the health burden of climate change, given their implementation role, knowledge of their local population, and proximity to the impacts of climate change on health (Frumkin et al., 2015; Sheehan et al., 2017; Bedsworth, 2009). Assistance is needed from upper-level² governments for local-level public health adaptation to climate change (Brown, 2016), but it is unclear what form that support should take beyond vague calls to build capacity (Hess et al., 2012).

In this paper, we examine how federal and regional governments can contribute to enabling and supporting public health adaptation to climate change at the local level in federal systems. We ground our main findings within the context of the local level's self-assessed adaptive capacity in Canada and Germany, two relatively comparable federal countries. We then draw upon interviewees' perspectives, complemented by considerations from the scientific literature and real-world examples, to propose concrete measures upper-level governments can take to fill local public health authorities' gaps in adaptive capacity. In focusing on this topic, we seek to inform how upper-level governments can support local public health adaptation, and develop usable knowledge for federal and regional decision-makers.

2. Methodology

This paper uses an adaptive capacity approach to characterize local public health authorities' ability to adapt to climate change and identify possible measures federal and regional governments may take to enable local public health adaptation. The research was carried out through semi-structured interviews in comparative case studies of Canada and Germany.

2.1. Conceptual framework

Adaptive capacity refers to “the resources for adaptation and the ability to use them effectively and efficiently, and implementing adaptive actions” (Hess et al., 2012). Adaptive capacity influences an individual's, group's or system's vulnerability to climate change by moderating its exposure (i.e. presence in places and settings that could be negatively affected) and sensitivity (i.e., the degree to which the individual, group or system is affected by harm or stress) (Smit et al., 2001; Smit and Wandel, 2006; Engle, 2011; Ford and Smit, 2004; Mortreux and Barnett, 2017; IPCC, Annex II: Glossary, 2014). The health impacts of climate change may exceed the adaptive capacity of local public health authorities (Appendix A) (Frumkin et al., 2015; Brown, 2016). Having adaptive capacity will not automatically translate into taking adaptation actions but it is an important precursor (Engle, 2011; Ford and King, 2015). In addition, adaptive capacity is unevenly distributed between and within countries, making it important to examine how it is, or can be, enhanced or undermined (Engle, 2011; Adger et al., 2007).

Adaptive capacity is context specific, meaning there is no single set of indicators of adaptive capacity applicable to every setting, and indicators must be tailored to each case (Mortreux and Barnett, 2017; Hinkel, 2011). A plethora of adaptive capacity indicators have been

proposed, including: economic resources, technology, information and skills, infrastructure, institutions, equity, priorities, kinship networks and political influence (Smit et al., 2001; Adger et al., 2007; Grambsch et al., 2003; Nguyen et al., 2017; Gupta et al., 2010). Drawing on this literature, we selected dimensions of adaptive capacity over which upper-level governments could have some influence, and that were most applicable to the context of local public health authorities (as opposed to, for example, countries, communities or individuals). Based on these parameters, in this Section 3.1 we outline local public health authorities' self-described adaptive capacity in terms of four dimensions: (i) funding – sufficient financial capital; (ii) knowledge and skills – adequacy of information, knowledge and training on vulnerability and adaptation in the health sector; (iii) organizations – cooperation between actors and policy authority; and (iv) prioritization – prioritization of climate change and adaptation relative to other public health issues (Fig. 1). This characterization is not an exhaustive measurement of adaptive capacity (Engle, 2011; Gupta et al., 2010), but introduces local public health authorities' needs and gaps for adaptation and serves as context for the proposed measures to build adaptive capacity in Section 4

2.2. Comparative case studies

This research was carried out in comparative nested case studies (Fig. 2). Canada and Germany were selected as two relatively comparable high income federal countries, in terms of their demographic and economic contexts (Table 1), where public health is primarily the responsibility of the provincial and *Länder* governments, respectively (Banting et al., 2002; Wilson, 2004; Austin et al., 2018).

The Canadian province of Quebec and the German *Land* of Baden-Württemberg were included based on their role as regional-scale leaders in public health adaptation (Umweltbundesamt, 2014; Austin et al., 2015). The cities of Montreal (Quebec) and Stuttgart (Baden-Württemberg) were included as the largest municipalities in their respective regions, while the cities of Sherbrooke (Quebec) and Karlsruhe (Baden-Württemberg) were selected for inclusion on the basis of progress on adaptation. Selecting regional and local jurisdictions that had made progress on adaptation provides an opportunity to learn from what has and has not worked in two regions that are advanced in their public health adaptation work. For example, Quebec is known for its progressive health, social and climate change policies (and complex relationship with the federal government) (Austin et al., 2015; Bernier, 2006; Gosselin et al., 2011). All four cities' encompassing local public health authority or equivalent were then also included: the Montreal Public Health Directorate, Stuttgart Urban District Public Health Office, Estrie Public Health Directorate and District of Karlsruhe Public Health Office. Of these four local public health authorities, only the Stuttgart Urban District Public Health Office is part of the municipal government. The other three local public health authorities are distinct institutions from the municipal governments.

2.3. Data collection and analysis

Thirty semi-structured interviews were conducted from June to October 2016. We interviewed participants from the federal, regional, and municipal governments, and local public health authorities, from the health and environment sectors in each of the sampled jurisdictions. We additionally conducted interviews with non-governmental key informants from universities, boundary organizations (organizations that facilitate collaboration and knowledge sharing between research and policy communities (Hoppe and Wesslink, 2014)), municipal climate change networks, and non-governmental organizations (NGOs), and a key informant from the United States Centers for Disease Control and Prevention (CDC) (Appendix B). Interviewees were selected through a combination of purposeful sampling (i.e. individuals working on adaptation and/or health in the given jurisdiction) and snowball

² Upper-level governments in this paper refers to federal and regional governments (i.e. provinces in Canada, *Länder* in Germany).

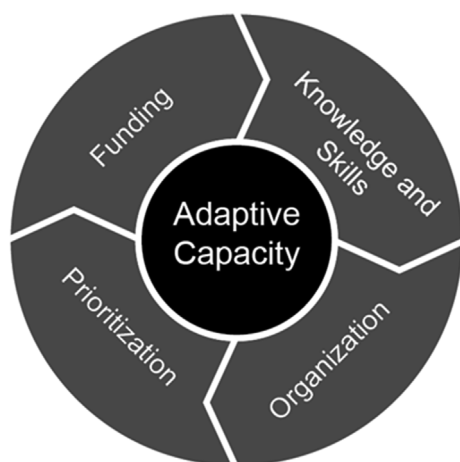


Fig. 1. Dimensions of adaptive capacity.

sampling.

The interview questions covered pre-defined themes of adaptive capacity, division of roles and responsibilities, and top-down and bottom-up influence, along with questions regarding the interviewee's role, the agency's administrative structure and progress on adaptation, and the role of NGOs (Appendix C). Interviewees were asked a variety of open questions related to adaptive capacity, such as the level of priority given to climate change adaptation relative to other health issues in the region, their level of knowledge on climate change impacts and adaptation, and their capacity (e.g. knowledge, resources and skills) to implement adaptation initiatives. Local-level interviewees were also asked questions regarding how upper-level governments have enabled or could support local public health adaptation. The same interview guides were used in both countries for comparative analysis. This consistent semi-structured interview style allowed interviewees to guide the discussion to areas of greatest importance or concern to them.

Interviews were conducted in English, French or German based on the preference of the interviewee, the latter with the assistance of an interpreter. Most interviews were conducted in person; four were conducted by telephone or Skype. All interviews were conducted by the lead author and took 40–130 min each to complete. Interviews were audio-recorded, then transcribed and analysed using Atlas.ti (version 7.5) coding software. Research ethics approval was obtained for this study prior to commencing interviews.

We used deductive coding methods to analyze the interviews for predefined topics of adaptive capacity and upper-level government measures supporting local-level public health adaptation. We then conducted inductive coding by examining repeating ideas to identify themes discussed by the interviewees that were not considered in advance by the research team (Auerbach and Silverstein, 2003). We organized local-level interviewees' responses to the adaptive capacity questions, along with other relevant comments from the interview, after we selected the four key dimensions to form a brief self-assessment of adaptive capacity (Section 3.1). We similarly used qualitative open coding methods to identify recurring themes from the interviews on positive experiences of upper-level governments enabling local-level public health adaptation, and local public health authorities' suggestions for how upper-level governments could support their adaptation work. We included measures recommended or suggested by more than one interviewee. We categorized these key themes as ten measures upper-level governments can take to enable or support local-level public health adaptation, generalizable to contexts outside Canada and Germany (Section 3.2). We then collected academic literature to provide greater foundation for these needs or proposed measures and coupled them with real world examples to make this more readily usable for upper-level governments.

3. Results

3.1. Local-level self-assessed adaptive capacity

In this section we describe the four sampled Canadian and German local public health authorities' self-assessed adaptive capacity, in terms of funding, knowledge and skills, organizations, and prioritization, based on our interview findings. We also provide some institutional context, for example, descriptions of regulations or budget decisions influencing local public health adaptive capacity. This section is a snapshot characterization, rather than an in-depth analysis of adaptive capacity, and is intended to provide context for the target areas and proposed measures federal and regional governments can take to enable local public health authorities' adaptive capacity (Section 3.2).

3.1.1. Funding

All four sampled local public health authorities described lacking the necessary funding to work on (or work more on) adaptation: "I'm scared that we embark on projects and [...] that we lack resources" (interviewee, Canadian local public health authority). Likewise, the limited funding restricted the number of staff available to work on adaptation: "There are a lot of fields we want to cover, it's a lot of work, and climate change is just one small part, because I'm the only person doing this" (interviewee, German local public health authority). In 2015 Quebec local Public Health Directorates had their budgets cut by 30% by the Quebec provincial government as part of broader provincial health care reforms and cost-saving measures. Interviewees were concerned about the possible effect these budget cuts would have on adaptation:

"in a climate where you're being cut left and right and your finances and your resources and so on, it's obviously going to be the first thing to go. It may not be the right response, but like anything else you cut in health care, what are you going to cut? Everything that's prevention. [...] Vision is short term in terms of finances" (interviewee, Canadian municipality).

In Baden-Württemberg, local actors, including local public health authorities, can apply for competitive adaptation funding through the Ministry of the Environment, Climate Protection and the Energy Sector (UM) Klimopass program. However, at the time of interviewing, no local public health authorities had applied. One German interviewee suggested this may be due to a lack of capacity or personnel to submit project proposals, negatively reinforcing this low capacity and lack of resources for adaptation among local public health authorities.

In Quebec, the Ministry of Sustainable Development, Environment and the Fight Against Climate Change (MDDELCC) provides funding to some municipalities for the development of adaptation strategies through the *Climat Municipalités* [Municipalities Climate] program. However, the local public health authorities do not receive dedicated adaptation funding:

"You will see, the City of Montreal has the climate change adaptation fund from the Quebec government for infrastructure, for all types of things, then there's the Federation of Canadian Municipalities that comes from the federal government. There are funds, but more for city functions than public health" (interviewee, Canadian local public health authority).

Overall, local public health authorities find themselves overburdened and struggling to take on additional adaptation activities with limited resources on top of their regular work:

"We have fixed tasks that we need to do, core tasks, and to do more on top of that is difficult, which would require more staff. We have to solve the urgent problems first, then we can see if we have some energy and space left" (interviewee, German local public health authority).

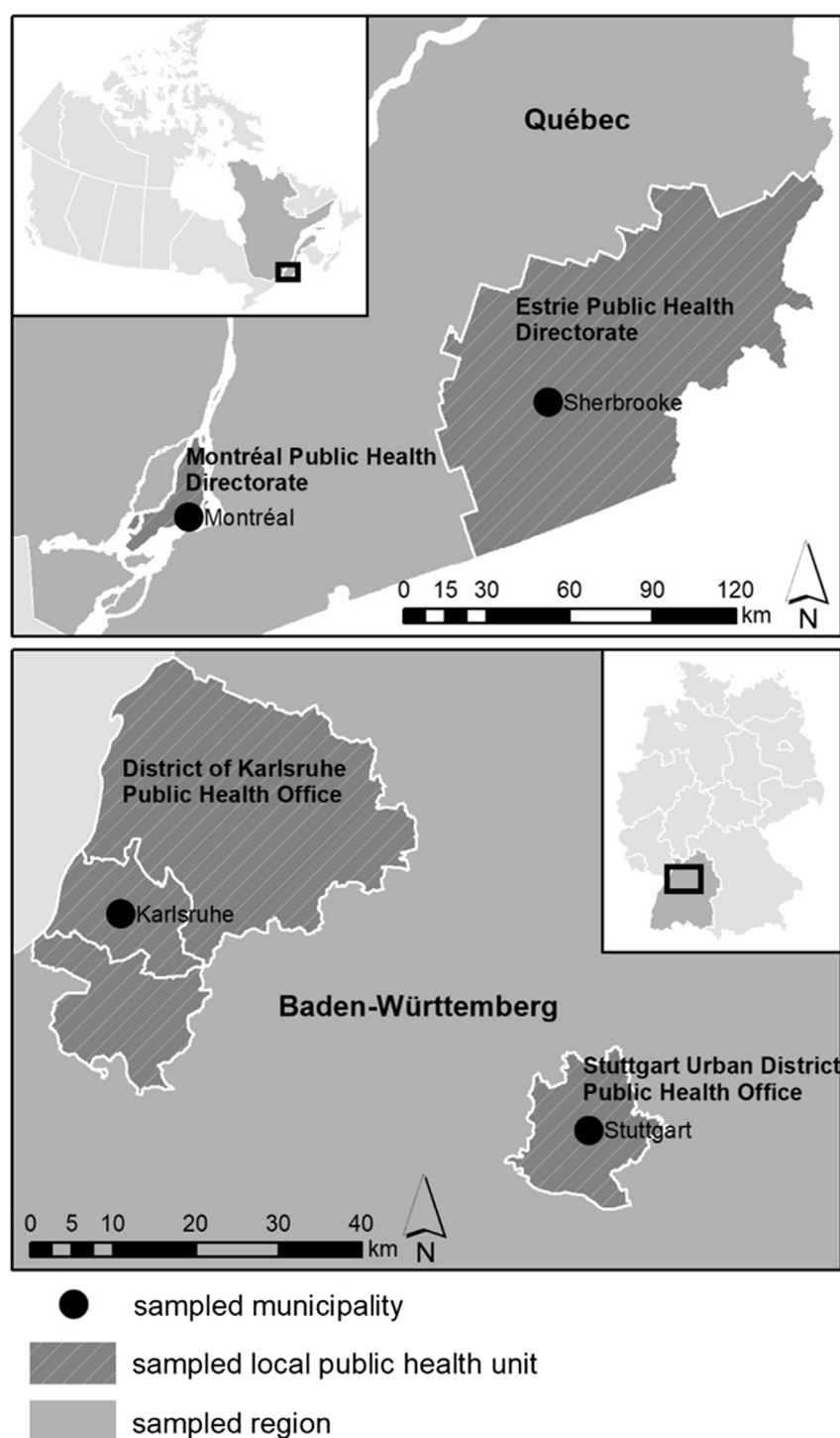


Fig. 2. Maps of nested case studies in Canada (top) and Germany (bottom). Map source: first author. Data source: Bundesamt für Kartographie und Geodäsie (Bundesamt für Kartographie, 2017), Statistics Canada (Statistics Canada, 2011), Statistics Canada (Statistics CanadaHealth Regions, 2015).

3.1.2. Knowledge and skills

Most local public health interviewees described their level of knowledge about climate change and its impacts on health to be sufficient or good. They likewise most often perceived themselves to have the necessary competencies to adapt to climate change, based on existing skills and experiences on public health issues, despite receiving little or no training.

The two local public health authorities in Quebec had a high level of knowledge and experiences on climate change and health issues, and had access to a wide range of information from the provincial

government. The Quebec National Institute for Public Health (INSPQ) contributed to local public health authorities' knowledge on climate change and health by providing targeted research, guidelines and data on climate change and health to local public health authorities. Quebec local public health authority interviewees emphasized the usefulness of several resources and tools from the INSPQ. For example, the *Mon climat, ma santé* [My climate, my health] website (www.monclimatmasante.qc.ca) provides information for both public health practitioners and the public on the health impacts of climate change in Quebec. Another example is the SUPREME (Surveillance and

Table 1
Demographic and economic contextual information.

	Canada		Germany	
Population (thousands) ^a	National	33476.7	National	82175.7
	Quebec	7903	Baden-Württemberg	10879.6
	Direction de Santé Publique de Montreal	1886.5	Stuttgart Urban District	623.7
	City of Montreal	1649.5	City of Stuttgart	623.7
	Direction de Santé Publique de l'Estrie	310.7	District of Karlsruhe	2762
	City of Sherbrooke	154.6	City of Karlsruhe	307.8
GDP per Capita (USD) (in 2014) ^b	National	42353	National	42450
	Quebec	34313	Baden-Württemberg	48609

^a Statistics Canada (Statistics Canada and Popula, 2016); Statistisches Bundesamt (Statistisches Bundesamt, 2015); Statistische Landesamt Baden-Württemberg (Statistische Landesamt Baden-Württemberg, 2015).

^b OECD (OECD, 2014).

Prevention of the impacts of Extreme Meteorological Events on public health) system developed by the INSPQ, which includes functions for data acquisition and integration, risk analysis and alerts, cartographic applications and climate change and health information (see [Toutant et al., 2011](#)).

In Baden-Württemberg, local public health authority interviewees' knowledge on climate change and health came primarily from their own initiative (e.g. online searches, informally requesting information from upper-level governments). Interviewees in both local public health authorities said they are not provided with information on climate change and health: "It's not common that we [the authorities] are supplied with information, we need to find it ourselves" (interviewee, German local public health authority). Such research and information exists, but it is not as readily applicable as the downscaled data and analysis packaged for local public health authorities in Quebec. Municipal government interviewees in Baden-Württemberg reported generally higher levels of knowledge on climate change impacts and adaptation planning than their Public Health Office counterparts.

3.1.3. Organizations

Some public health bodies considered their capacity to be lower if they were separate from the municipal government, rather than part of it, as in three of the sampled local jurisdictions (Montreal, Estrie and Karlsruhe). When they are separate institutions, coordination issues are common, reducing both bodies' adaptive capacity. Moreover, as separate institutions with different funding channels, public health interviewees pointed out that municipal governments do not benefit financially from any health care savings derived from preventative public health adaptation interventions. Public health must convince municipal governments to implement preventative measures simply because the municipality wants to benefit the public. Coordination challenges between local public health authorities and municipalities, and the consequent capacity issues, are further compounded in jurisdictions such as Estrie, where the Public Health Directorate covers a geographic area that includes a large number of municipalities:

"Here public health is separated from the municipalities. We have 121 municipalities, that makes a lot of work. [...] But it requires a lot of energy, because the City of Sherbrooke, we call, we text, we need to be friends, otherwise it doesn't work. But with 121 municipalities, I don't know. It's really a challenge" (interviewee, Canadian local public health authority).

Local public health authorities in our study were almost unanimously considered to have an implementation role in public health adaptation by interviewees at all levels of government. However, public health often lacks the jurisdictional authority to implement many public health adaptation initiatives. For example, public health authorities may want to increase green canopy to reduce the urban heat island effect and associated heat-related morbidity or mortality, but does not have jurisdiction in the city over tree planting:

"public health, they'll promote having more trees and parks and access to shores and so on, but they have no jurisdiction over that. They're just promoting an idea. They can't make the city do anything. The city has to decide to do something" (interviewee, Canadian municipality).

3.1.4. Prioritization

The level of priority given to climate change relative to other public health issues varied between the sampled local public health authorities. Interviewees in Quebec accorded adaptation a relatively high level of priority because the 2015–2025 Quebec national public health program requires all regional Public Health Directorates to consider climate change in their regional public health plans:

"I would say it's a priority. It's a priority because we must never forget that the regional public health plan is particular with the national public health program [...] so the climate change component under the environmental health section is a priority" (interviewee, Canadian local public health authority).

Climate change was a much lower priority for the Karlsruhe Public Health Office, for example, which was overwhelmed by other public health issues at the time of the interviews. For the Karlsruhe Public Health Office, certain public health issues relating to climate change are considered high priority at times, such as mosquito-borne infectious diseases or above-average temperature, rather than climate change as a whole.

Among Baden-Württemberg local public health authority interviewees, the lack of a legal framework or legal security was considered to be a barrier to working further on public health adaptation: "There also needs to be the legal security that you know what you're doing, because the implementing takes place at the local level but you need the structure from above" (interviewee, German local public health authority).

3.2. Proposed measures to support local-level public health adaptation

In this section, we discuss concrete measures federal and regional governments could take to better support or enable local-level public health adaptation. The ten measures listed were suggested or recommended by interviewees, which we complemented by noting examples from other jurisdictions and considerations from the scientific literature. These measures can be grouped into four action-oriented, overlapping target areas that address each of the four dimensions of adaptive capacity discussed above: build financial capital (funding); develop and disseminate usable knowledge (knowledge and skills); collaborate and coordinate for shared knowledge (organizations); and claim leadership (prioritization) ([Fig. 3](#)). We have purposefully sought to keep these measures relatively generalizable, however, selecting or implementing any of the below measures will require consideration of

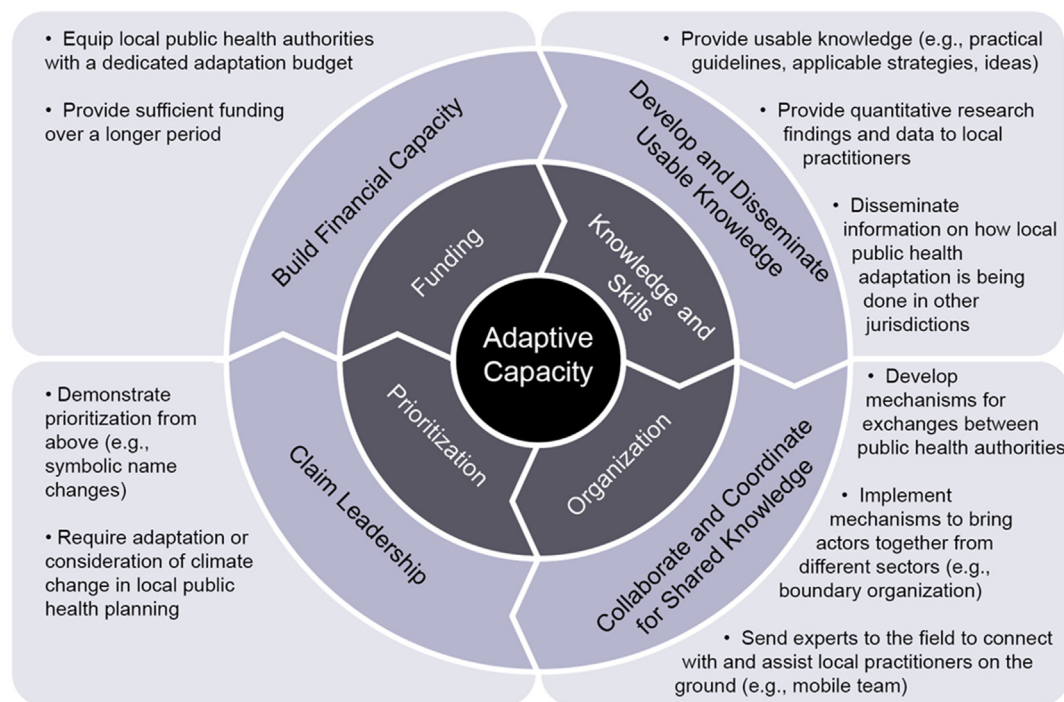


Fig. 3. Proposed measures to enable local public health authorities' adaptive capacity organized by adaptive capacity dimension (middle circle) and target area (outer circle).

the appropriateness for the economic, political and social context, and consequently may necessitate some modifications.

3.2.1. Build financial capacity

Equip local public health authorities with a dedicated adaptation budget. Interviewees argued for earmarked adaptation budgets because:

“then we would be capable of starting our own projects and not relying on something, because it's always bound. Like when the state gives money and it's for XYZ, and with your own budget you can decide what kind of project we would like to start” (interviewee, German local public health authority).

The public health sector has a propensity for unfunded mandates and prioritization of urgent public health issues, such as disease outbreaks, smoking or obesity (Wilson, 2004). Without explicit mandates and earmarked funding, adaptation and projected future public health risks will rarely be prioritized. In such a context, and in contrast to recommendations in other sectors, mainstreaming adaptation into existing funding may not be the best approach for the public health sector, but rather dedicated adaptation funds and mechanisms could be necessary to ensure that adaptation funding and capacity are not absorbed into other priorities.

Provide sufficient funding over a longer period. Perhaps unsurprisingly, interviewees all agree having sufficient funding is crucial for adapting to climate change. Interviewees argued funding must be provided over longer terms, rather than simply for short and targeted projects, to ensure foreseeable funding security, enable longer term agreements with partners, and to allow for well planned projects, a consideration also established in scientific literature (Ford and King, 2015; Baker et al., 2012; Ford et al., 2011). There must also be sufficient funding to bring about changes such as hiring additional staff in local public health offices:

“if they get more money they can't do more because they also only have 24 hours a day. It has to be so much that they can put someone for half time there to do something about adaptation, and there's

always lots of personnel costs. Because for just a few thousand euros it's very hard to do something” (interviewee, South German Climate Office).

Lastly, one of the local public health authority interviewees argued funding should be provided directly to local public health bodies that have sufficient policy capacity and innovation on their own to deal with public health interventions and adaptation on the ground, rather than holding the funding within upper-levels of government.

3.2.2. Develop and disseminate usable knowledge

Provide usable knowledge. Access to information is insufficient for adaptation – actors must also be able to transform that information into usable and applicable knowledge for evidence-based decisions (Williams et al., 2015). Interviewees emphasised the need for training and guidelines that translate theory into practice and include examples of best practices with logistical information such as “how does implementation work, what funding looks like, how many staff are working on it, what the specific context or conditions are” (interviewee, German municipality). Other interviewees suggested upper-level governments could develop adaptation frameworks for local authorities to adopt, facilitate region-wide pilot projects, or provide specific ideas for adaptation measures: “More ideas, not in general more information, we have a lot of information [but] we can't process it all. But [we need] more ideas. Really good ideas and maybe projects or things to implement” (interviewee, German local public health authority). The need for usable knowledge has been identified elsewhere, and practical examples include the US CDC BRACE framework which proposes five steps for sub-national public health agencies to conduct health vulnerability assessments and adaptation (Marinucci et al., 2014) and the BASE project ‘Adaptation Inspiration Book’ of case studies of adaptation measures in Europe (Ng et al., 2016). Lastly, for knowledge to be usable it must be translated into regional languages (e.g., French, German) and be accessible to a public health audience. The provision of usable knowledge is part of a larger role for upper-level governments in identifying promising pilot projects and spreading the ideas to other jurisdictions to emulate.

Provide quantitative research findings and data to local practitioners. Local public health authority interviewees in Germany said they do not receive research or surveillance data from the Baden-Württemberg government, although they can call and request information. In contrast, in Quebec, local public health authorities receive a variety of data and research findings from the provincial government which they find concrete and helpful. These include, for example, annual epidemiological analyses of the health impacts of extreme heat by region (Lebel et al., 2016), and the SUPREME system, discussed in Section 3.2 In regard to the need for quantitative research findings and data, one interviewee noted that:

“most of the studies I've seen in the past, I see more that they deliver information which is more qualitative, but I want to know quantitative. The planner in the city wants to know if we build a city in that way or this pavement will be changed to green or green to pavement, how will this change under climate change conditions” (interviewee, Deutscher Wetterdienst).

Estimating or quantifying the additional burden on health due to climate change (i.e. projecting the disease burden) is one such data need and has been identified as a challenging but important step in public health adaptation that can be used in cost-benefit analyses (Sheehan et al., 2017; Marinucci et al., 2014). Projecting the disease burden of climate change is highly data intensive, however, and requires downscaled and tailored climate projection data, meteorological data and health outcome data for a specific region (Peng et al., 2011; Sheffield et al., 2011).

Disseminate information on how local public health adaptation is being done in other jurisdictions. Upper-level governments have a higher-level overview of public health adaptation activities in other jurisdictions, both domestically and internationally. This information must then be disseminated ‘back down the ladder’ to local public health authorities, however, to allow them to consider a variety of adaptation possibilities and contact other jurisdictions who have faced or overcome similar challenges. One interviewee said governments may already be:

“collecting the information but it doesn't reach me. [...] I always think, ‘oh in Germany everything is very well so we know how to do things’ but maybe not. What I don't have is information on how it is in other countries. And this is something that I would like to know.” (interviewee, German local public health authority).

Interviewees suggested it could be helpful to look to countries that currently have the climatic conditions projected for their region:

“I would like to know what is Rome doing. The person like me in Rome. I mean, Rome, it must be very hot. So they must do something, there has to be something. Or Barcelona, I don't know. So this would be quite interesting. Then we could compare and measure our success” (interviewee, German local public health authority).

This could entail, for example, setting up networks of knowledge exchange, such as the Climate Adaptation Knowledge Exchange (CAKE) which maintains an online library of adaptation case studies, or creating databases of public health adaptation activities such as the German national Program for the Environment and Health (APUG) database.

3.2.3. Collaborate and coordinate for shared knowledge

Develop mechanisms for exchanges between public health authorities. In order to coordinate and link people working on adaptation and reduce duplication, one interviewee suggested federal and regional governments could be:

“creating exchanges on best practices. It's taking what is being done, it's promoting exchanges between regions. [...] The exchange between tools, the exchange between professionals, all professionals.

[...] In my opinion that's what the higher-level governments should be doing. Developing support programs. Instead of recreating the same box or the same tool” (interviewee, Canadian local public health authority).

One form this could take is:

“a huge meeting for all the departments and they present to all of us. I know they want to talk separately to Karlsruhe, to Stuttgart, all the cities, but it is not possible. But to make a huge workshop or just a one day presentation” (interviewee, German local public health authority).

Another form could be networked learning partnerships for collaboration or knowledge sharing between jurisdictions (Sheehan et al., 2017). It could also link into existing platforms, such as the recently established Communal Health Conferences in Baden-Württemberg, with discussion time devoted to adaptation. Similarly, many local public health interviewees said they lacked contacts in upper-level governments, which constrained their adaptation activities. Creating a directory of key contact people for different climate change and health issues in upper-level governments would help ensure local public health practitioners have sufficient information and guidance to enable adaptation.

Implement mechanisms to bring actors together from different sectors. Local public health authorities interviewed agreed, “climate change adaptation is a very complex topic and not every topic we cover we have to contact as many actors as we do for this topic” (interviewee, German municipality). Connecting with actors from other sectors or levels of government is challenging, and as one interviewee likewise points out: “these actors don't actually come together naturally [...] it needs something, someone, to be able to do this to develop projects in this way” (interviewee, Ouranos). One local public health authority interviewee proposed a platform ‘expertise to give, expertise sought’: “If there was a place, a website or an address for requests, ‘I have an interesting project, is there someone who would like to work with us?’” (interviewee, Canadian local public health authority). Such a platform could be regional, national, or international, and would help local public health authorities find partners for adaptation initiatives. Boundary organizations – whose primary goals are typically to link science and policy – are another possible such mechanism to bridge actors (Ford and King, 2015). The Ouranos Consortium in Quebec is an example of a boundary organization that seeks to support adaptation at all levels of government in the province through climate scenarios and services, and co-financing for interdisciplinary and multi-institutional projects. Local public health authorities would benefit from strong cross-sectoral relationships by receiving reliable climate services and other information, while providing public health expertise in return to adaptation initiatives in other sectors (Frumkin et al., 2015).

Send experts to the field to connect with and assist local practitioners on the ground. Local public health interviewees were adamant that public health interventions must happen on the ground. Interviewees argued that for knowledge transfer on public health adaptation to be most effective, experts must come to the field:

“what we need is for people's expertise to really contribute and that they're ready to come here. We don't want people to send us documents and studies. It's real knowledge transfer that we need, meaning that we sit with people, listen to their needs, and produce documents, and influence. If they stay in Ottawa [Canada's capital] ... [...] If you want to work with us you need to help us produce things, you need to read our documents, you need to be part of the team. That's a nice offer of help” (interviewee, Canadian local public health authority).

One example of this in practice is the Danish Ministry of Environment's mobile team which visits municipalities in person to guide them in adaptation and facilitate collaboration with other

stakeholders (European Environment Agency, 2014).

3.2.4. Claim leadership

Demonstrate prioritization from above. Interviewees among both local public health authorities and municipal governments found it not only encouraging to see upper-level governments engaging on adaptation issues themselves, but also helpful in making adaptation a priority within their own department or agency. Several interviewees highlighted what they perceived to be a signal of prioritization of climate change issues when upper-level governments changed their name to include climate change (e.g., Environment and Climate Change Canada), as this “shows the importance and says ‘this interests us’” (interviewee, Canadian local public health authority). Despite the fact that these kind of so-called ‘symbolic policies’ do not directly increase resilience or reduce vulnerability to climate change (Dupuis and Biesbroek, 2013), they can serve to show enabling leadership and prioritization to lower-level governments (Meijerink and Stiller, 2013). Meijerink and Stiller (2013) suggest upper-level governments may also claim leadership through three other functions that correspond to the three other target areas in this section: first, communication of adaptation objectives and allocation of resources for adaptation (Section 4.1); second, dissemination of ideas within networks (Section 4.2); and third, connecting actors and stimulate collaboration (Section 4.3).

Require adaptation or consideration of climate change in local public health planning. Local public health authorities in the German case study wanted to be legally obliged to adapt to climate change or consider climate change in their work because they wanted it to be regulated and provide legal security. German interviewees believed needed financing and political backing would follow legislation. In Quebec, Public Health Directorates are required to include consideration of climate change in their Regional Action Plans 2015–2025, a move that was viewed positively by Public Health Directorate interviewees. Interviewees noted that requiring adaptation or requiring reporting of adaptation progress may provide a stimulus to adapt to climate change: “As scientists we can say a lot to the communities, but as long as they don't get the green light from the top to do something they don't do anything” (interviewee, South German Climate Office), as was the case with the United States Executive Order 13514 and the United Kingdom Climate Change Act (Jude et al., 2017; Hess et al., 2014). Any requirements of adaptation are best accompanied by dedicated funding and guidance, or risk adding unfunded mandates (Wilson, 2004) or enabling maladaptation. This measure is highly context dependent because it must fit the jurisdictions' style of intergovernmental relations. It is likely only regional governments that have the policy authority and jurisdictional mandate to require local public health adaptation in federal systems. Such a hierarchical approach represents a steering paradox in federal systems that must balance prioritization of autonomy, against top-down coordination and facilitation needs (Bolleyer and Börzel, 2010).

4. Discussion and conclusions

In this paper we have argued that local public health authorities often lack necessary adaptive capacity, or the prioritization to mobilize this capacity, despite being considered to have the implementation role in public health adaptation, similar to other studies (Nalau et al., 2015). Local public health authorities have the potential to play a critical role in increasing populations' resilience or reducing vulnerability to the health impacts of climate change because of their knowledge of the local population and the localized nature of climate change impacts (Frumkin et al., 2015). Although some larger local public health authorities will already have the necessary adaptive capacity, wide disparities exist with the adaptive capacity of smaller local public health authorities. Upper-level governments can guide effective adaptation and ensure equity in adaptation and adaptive capacity among vulnerable populations and smaller communities: “we need to level the

playing field [...] It's about building capacity, it's about making sure that actors that don't have those resources, public health officials can take those actions” (interviewee, Health Canada).

There is broadly consensus in the scientific literature that upper-level governments have a role to play in providing assistance to local public health authorities for public health adaptation (Brown, 2016), but the literature does not go beyond vague calls to build local-level capacity. In this paper we have drawn upon interviewees' perspectives and local public health authorities' needs, complemented by adaptation literature, to develop a variety of specific, concrete measures upper-level governments can take to enable local public health authorities' adaptive capacity. These measures would help provide the necessary resources for adaptation, but also enable local public health authorities to use them effectively and efficiently: the two crucial elements for adaptive capacity. We organize these measures based on the adaptive capacity framework under the action-oriented target areas of i) providing financial capital, ii) developing and disseminating usable knowledge, iii) collaborating and coordinating for shared knowledge, and iv) claiming leadership. Selecting which measures to implement will require consideration of the appropriateness and need in the local context, just as implementing them will require some tailoring. Once the elements of adaptive capacity are available, and in the absence of requirements for adaptation, local public health authorities will need to balance prioritization of long-term adaptation planning with immediate pressing public health concerns.

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Appendix A. Supplementary data

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References

- Adger, W.N., et al., 2007. Assessment of adaptation practices, options, constraints and capacity. In: Parry, M.L. (Ed.), *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 717–743.
- Amundsen, H., Berglund, F., Westskog, H., 2010. Overcoming barriers to climate change adaptation - a question of multilevel governance? *Environ. Plann. C Govern. Pol.* 28, 276–289.
- Auerbach, C., Silverstein, L.B., 2003. *Qualitative Data: an Introduction to Coding and Analysis*. NYU press.
- Austin, S.E., et al., 2015. Public health adaptation to climate change in Canadian jurisdictions. *Int. J. Environ. Res. Publ. Health* 12 (1), 623–651.
- Austin, S.E., et al., 2018. Intergovernmental relations for public health adaptation to climate change in the federalist states of Canada and Germany. *Global Environ. Change* 52, 226–237.
- Baker, I., et al., 2012. Local government response to the impacts of climate change: an evaluation of local climate adaptation plans. *Landsc. Urban Plann.* 107 (2), 127–136.
- Banting, K.G., Corbett, S., 2002. Introduction. In: Banting, K.G., Corbett, S. (Eds.), *Health Policy and Federalism: a Comparative Perspective on Multi-level Governance*, pp. 1–39.
- Bedsworth, L., 2009. Preparing for climate change: a perspective from local public health officers in California. *Environ. Health Perspect.* 117 (4), 617.
- Bernier, N.F., 2006. Quebec's approach to population health: an overview of policy content and organization. *J. Publ. Health Pol.* 27 (1), 22–37.
- Bolleyer, N., Börzel, T.A., 2010. Non-hierarchical policy coordination in multilevel systems. *Eur. Polit. Sci. Rev.* 2 (02), 157–185.
- Brown, L., 2016. Preparing for the public health challenges of climate change:

- perspectives from local public health. *J. Publ. Health Manag. Pract.* 22 (1), 102–104.
- Bundesamt für Kartographie und Geodäsie. Administrative areas 1:250,000 - Stand 01.01.2017.
- Burton, I., 2011. Adaptation to climate change: context, status, and prospects. In: Ford, J.D., Berrang-Ford, L. (Eds.), *Climate Change Adaptation in Developed Nations*. Springer, Dordrecht, The Netherlands, pp. 477–483.
- Dupuis, J., Biesbroek, R., 2013. Comparing apples and oranges: the dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environ. Change* 23 (6), 1476–1487.
- Engle, N.L., 2011. Adaptive capacity and its assessment. *Global Environ. Change* 21 (2), 647–656.
- European Environment Agency, 2014. National adaptation policy processes in European countries — 2014. In: EEA Report, Copenhagen, Denmark.
- IPCC, 2012. Managing the risks of extreme events and disasters to advance climate change adaptation. In: Field, C.B. (Ed.), *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York, NY, USA.
- Ford, J.D., King, D., 2015. A framework for examining adaptation readiness. In: *Mitigation and Adaptation Strategies for Global Change*, pp. 1–22.
- Ford, J.D., Smit, B., 2004. A framework for assessing the vulnerability of communities in the Canadian arctic to risks associated with climate change. *Arctic* 57 (4), 389–400.
- Ford, J.D., Smith, T.R., Berrang-Ford, L., 2011. Canadian federal support for climate change and health research compared with the risks posed. *Am. J. Public Health* 101 (5), 814–821.
- Frumkin, H., Hess, J., Lubner, G., 2015. Public health policies and actions. In: Barry, L., Jonathan, P. (Eds.), *Climate Change and Public Health*. Oxford University Press, Oxford, UK.
- Gosselin, P., et al., 2011. The burgeoning field of transdisciplinary adaptation research in Quebec (1998–): a climate change-related public health narrative. *J. Multidiscip. Healthc.* 4, 337.
- Grambsch, A., Menne, B., 2003. Adaptation and adaptive capacity in the public health context. In: McMichael, A. (Ed.), *Climate Change and Health: Risks and Responses*. World Health Organization, Geneva, pp. 220–236.
- Gupta, J., et al., 2010. The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environ. Sci. Pol.* 13 (6), 459–471.
- Hess, J.J., McDowell, J.Z., Lubner, G., 2012. Integrating climate change adaptation into public health practice: using adaptive management to increase adaptive capacity and build resilience. *Environ. Health Perspect.* 120 (2), 171.
- Hess, J.J., Schramm, P.J., Lubner, G., 2014. Public health and climate change adaptation at the federal level: one agency's response to executive order 13514. *Am. J. Public Health* 104 (3), e22–e30.
- Hinkel, J., 2011. “Indicators of vulnerability and adaptive capacity”: towards a clarification of the science–policy interface. *Global Environ. Change* 21 (1), 198–208.
- Hoppe, R., Wesselink, A., 2014. Comparing the role of boundary organizations in the governance of climate change in three EU member states. *Environ. Sci. Pol.* 44, 73–85.
- Huang, C., et al., 2011. Constraints and barriers to public health adaptation to climate change: a review of the literature. *Am. J. Prev. Med.* 40 (2), 183–190.
- IPCC, Annex II: Glossary, Agard, J., Schipper, E.L.F., Birkmann, J., Campos, M., Dubeux, C., Nojiri, Y., Olsson, L., Osman-Elasha, B., Pelling, M., Prather, M.J., Rivera-Ferre, M.G., Ruppel, O.C., Sallenger, A., Smith, K.R., St Clair, A.L., Mach, K.J., Mastrandrea, M.D., Bilir, T.E. (Eds.), 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1757–1776 V.R. Barros, et al.
- Jude, S.R., et al., 2017. Delivering organisational adaptation through legislative mechanisms: evidence from the adaptation reporting power (climate change Act 2008). *Sci. Total Environ.* 574, 858–871.
- Lebel, G., Bustinza, R., Dubé, M., 2016. In: *Surveillance des impacts sanitaires des vagues de chaleur extrême au Québec – Bilan de la saison estivale 2015*, Direction de la santé environnementale et de la toxicologie. Institut national de santé publique du Québec, Québec.
- Marinucci, G.D., et al., 2014. Building resilience against climate effects—a novel framework to facilitate climate readiness in public health agencies. *Int. J. Environ. Res. Publ. Health* 11 (6), 6433–6458.
- McMichael, A.J., 2015. A widening research agenda: challenges and needs. In: Barry, L., Jonathan, P. (Eds.), *Climate Change and Public Health*. Oxford University Press, Oxford, UK.
- Measham, T., et al., 2011. Adapting to climate change through local municipal planning: barriers and challenges. *Mitig. Adapt. Strategies Glob. Change* 16 (8), 889–909.
- Meijerink, S., Stiller, S., 2013. What kind of leadership do we need for climate adaptation? A framework for analyzing leadership objectives, functions, and tasks in climate change adaptation. *Environ. Plann. C Govern. Pol.* 31 (2), 240–256.
- Mortreux, C., Barnett, J., 2017. *Adaptive capacity: exploring the research frontier*. Wiley Interdiscipl. Rev. Clim. Change 8 (4).
- Nalau, J., Preston, B.L., Maloney, M.C., 2015. Is adaptation a local responsibility? *Environ. Sci. Pol.* 48, 89–98.
- Ng, K., Campos, I., Penha-Lopes, G., 2016. *BASE Adaptation Inspiration Book: 23 European Cases of Climate Change Adaptation to Inspire European Decision-makers, Practitioners and Citizens*. Faculty of Sciences, University of Lisbon, Lisbon.
- Nguyen, Q.A., et al., 2017. Evaluating capacity for climate change adaptation in the health and water sectors in Vietnam: constraints and opportunities. *Clim. Dev.* 9 (3), 258–273.
- OECD, 2014. *Regional Economy*.
- Peng, R.D., et al., 2011. Toward a quantitative estimate of future heat wave mortality under global climate change. *Environ. Health Perspect.* 119 (5), 701.
- Roser-Renouf, C., Maibach, E.W., Li, J., 2016. Adapting to the changing climate: an assessment of local health department preparations for climate change-related health threats, 2008–2012. *PloS One* 11 (3), e0151558.
- Sheehan, M.C., et al., 2017. Integrating health into local climate response: lessons from the US CDC climate-ready states and cities initiative. *Environ. Health Perspect.* 94501, 1.
- Sheffield, P.E., et al., 2011. Modeling of regional climate change effects on ground-level ozone and childhood asthma. *Am. J. Prev. Med.* 41 (3), 251–257.
- Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. *Global Environ. Change* 16 (3), 282–292.
- Smit, B., et al., 2001. Adaptation to climate change in the context of sustainable development and equity. In: McCarthy, J.J. (Ed.), *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel of Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 879–912.
- Smith, K.R., et al., 2014. Human health: impacts, adaptation, and co-benefits. In: Field, C.B. (Ed.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 709–754.
- Statistics Canada, 2011. *Boundary Files, 2011 Census* (92-160-X).
- Statistics Canada, Population And Dwelling Count Highlight Tables, 2011 Census. Statistics Canada, Ottawa, Canada.
- Statistics Canada, Health Regions, 2015. *Boundaries and Correspondence with Census Geography* (82-402-X).
- Statistische Landesamt Baden-Württemberg, 2015. *Eckdaten zur Bevölkerung. Statistisches Bundesamt, Population Based on the 2011 Census*.
- Toutant, S., et al., 2011. An open source web application for the surveillance and prevention of the impacts on public health of extreme meteorological events: the SUPREME system. *Int. J. Health Geogr.* 10 (1), 39.
- Umweltbundesamt, 2014. *Erhebung von Aktivitäten und Maßnahmen zu „Klimawandel und Gesundheit“*.
- Williams, C., Fenton, A., Huq, S., 2015. Knowledge and adaptive capacity. *Nat. Clim. Change* 5 (2), 82–83.
- Wilson, K., 2004. The complexities of multi-level governance in public health. *Can. J. Public Health/Rev. Can. Sante Publique* 95 (6).